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NOTES ON THE NORTHERN GULF OF MEXICO OCCURRENCE OF *SAGITTA FRIDERICI* RITTER-ZAHONY (CHAETOGNATHA)

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ABSTRACT The neritic chaetognath *Sagitta friderici* Ritter-Zahony, 1911 was identified in plankton samples from the northern Gulf of Mexico in June 1974. Specimens analyzed from two groups of adults ranged from 6 to 13.7 mm long. Meristic values did not appear to be a function of body length except for individuals in the 12.4 to 13.7 mm range that had larger numbers of hooks and teeth.

Adults of *Sagitta friderici* and the closely related *S. tenuis* Conant, 1896 were compared and found to be distinguishable chiefly by (1) the number of ova per unit length of the ovary, and (2) the arrangement of ova within the ovary. The TC values were highly variable and overlapping, thus casting doubt on the taxonomic importance of that characteristic.

Sagitta friderici was abundant in inshore continental shelf waters where the salinity and temperature ranged from 24.9 to 33.9 ppt and 23.0 to 30.3°C, respectively. The failure to determine ecological boundaries between *S. friderici* and *S. tenuis* revealed a need for more intensive sampling in coastal regions of the Gulf of Mexico.

INTRODUCTION

Sagitta friderici Ritter-Zahony, 1911 is generally described as a neritic, epiplanktonic chaetognath preferring lower salinity water near shore, but also able to tolerate oceanic salinities (Furnestin 1957, Colman 1959, Fraser 1961, Almeida-Prado 1968). Originally described from Cape Verde specimens by Ritter-Zahony (1910), it has been investigated extensively in the Mediterranean Sea and along the African and South American coasts in the Atlantic Ocean. Mattlin (1974) reported one juvenile specimen in the Caribbean Sea. Because Colman (1959) collected specimens of *S. friderici* over deep water in the eastern central Atlantic, a connecting bridge extending from east to west along the Guinea and Equatorial Currents in the South Atlantic was suggested by Vannucci and Hosoe (1952), Almeida-Prado (1961a), and Alvariño (1969).

In the eastern Pacific, *S. friderici* has been reported from the coast of Peru northward to the southern California coast of North America (Bieri 1957, 1959; Tokioka 1959, 1961). Confusion arose, however, with the descriptions of new, morphologically similar species, *S. euneritica* Alvariño from the California coast, and *S. peruviana* Sund and *S. popovicii* Sund from Peruvian waters (Alvariño 1961, Sund 1961). Tokioka (1961, 1965) did not accept the validity of these new species and maintained that *S. friderici* and *S. tenuis* Conant, 1896, being in the eastern Pacific, represented populations that immigrated from the Atlantic via a once-opened passage through Central America.

The only published record of *S. friderici* in the Gulf of Mexico is that of Laguarda-Figueras (1967) who studied the systematics and distribution of the species in the Laguna de Terminos (Campeche, Mexico). *Sagitta friderici* was the only chactognath in two collections made in June 1965 and February 1966. Laguarda-Figueras' excellent descriptions and illustrations confirmed an earlier, tentative identification of the species by Suarez-Caabro and Gomez-Aguirre (1965) who investigated the Lagoon's zooplankton community.

Sagitta friderici has not been previously reported from the many plankton investigations along the Gulf and Atlantic coasts of the United States, presumably because of its confusion with the morphologically similar *S. tenuis*. Pierce (1951), in his pioneer work on the Chaetognatha of the west Florida coast, synonymized the two species because Ritter-Zahony's (1911) description of *S. friderici* was similar to the Florida specimens of *S. tenuis*. Tokioka (1955), on examining Pierce's specimens, concurred with their identification of *S. tenuis*, but also left open the possibility, as did Faure (1952) and Almeida-Prado (1961b) on reviewing Pierce's meristic data, that certain individuals might be immature specimens of *S. friderici*.

This paper discusses the occurrence of *S. friderici* in the northern Gulf of Mexico, and the methods currently used to separate the species from *S. tenuis*. This work is based, in part, on a thesis concerning the distribution of chaetognaths in the northeastern Gulf of Mexico (McLelland 1978).

MATERIALS AND METHODS

Plankton samples and hydrographic data were collected in June 1974 by Gulf Coast Research Laboratory (GCRL) personnel as part of a U.S. Bureau of Land Management (BLM) baseline environmental survey of oil lease areas in the northeastern Gulf of Mexico, conducted by the State University System of Florida Institute of Oceanography Consortium (SUSIO/BLM Contract No. 08550–CT4–11, Final Report). Fifty-four zooplankton samples were examined from 12 stations over the continental shelf and slope with bottom depths ranging from 25 to 364 m (Figure 1). At each station the surface, mid-depth, and bottom strata were simultaneously sampled with Niskin 0.5 m, 202-mesh plankton nets equipped with double-trip, opening-and-closing devices and digital flowmeters. Samples were preserved in 5% buffered

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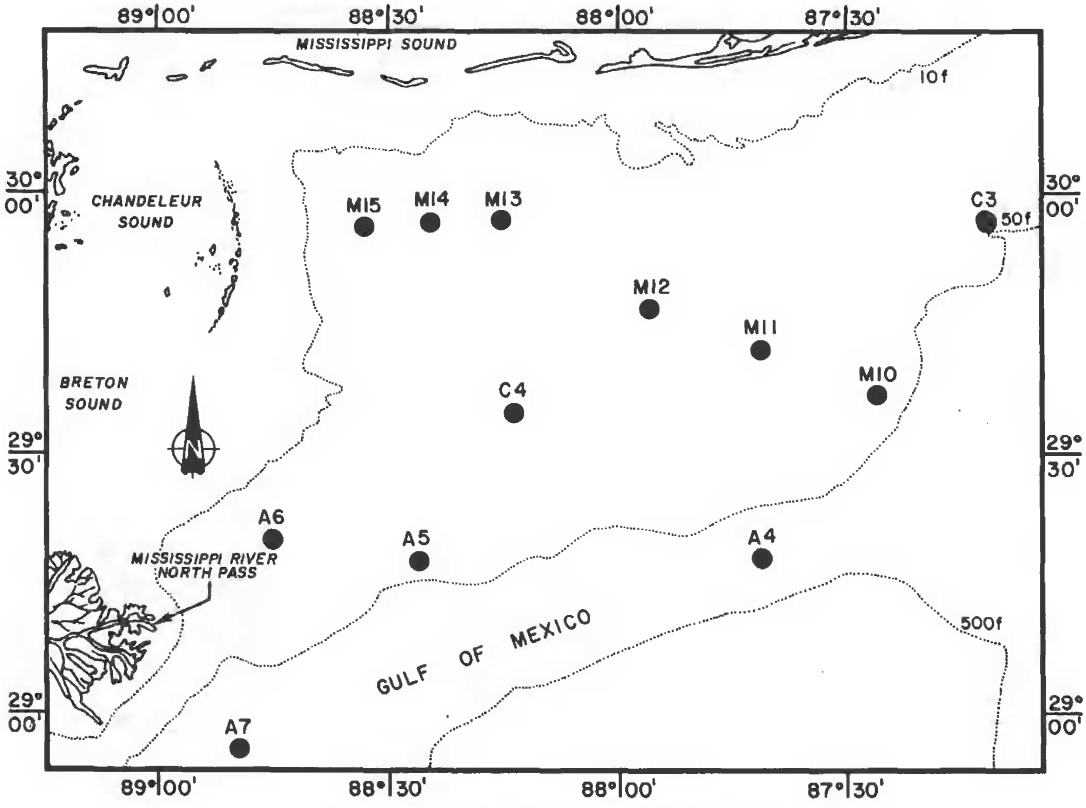

Figure 1. Station locations in the northern Gulf of Mexico.

formalin, aliquoted with a Folsom plankton splitter, and examined for chaetognaths under a stereoscopic dissecting microscope equipped with an ocular micrometer for measuring specimens.

Unstained specimens were examined under high magnification; dark-field illumination was occasionally used for better resolution of lateral and caudal fins. *Sagitta friderici* was identified with the aid of descriptions and illustrations from Faure (1952), Almeida-Prado (1961b), Alvariño (1969), and Laguarda-Figueras (1967).

Specimens of *S. friderici* and *S. tenuis* with fully developed ovaries were selected from preserved BLM samples for analysis of morphological features. Additional specimens of *S. friderici* were obtained from surface samples collected around the Mississippi River delta by Mr. John Steen (GCRL) aboard the NOAA R/V OREGON II on March 3, 1975.

DESCRIPTION OF THE STUDY AREA

Stations were located along the continental slope east of the Mississippi River delta to a point south of Pensacola Bay, Florida, and on the continental shelf east of the Chandeleur Islands, Louisiana. Large environmental variations occur in this area from seasonal interactions of winds, tides, river discharges, and offshore currents (Drennan 1968). The Loop Current (see Figure 2), which enters the Gulf through the Yucatan Straits, is recognized as the main driving force for water circulation in the northeastern Gulf during the summer months (Eleuterius 1974). It is countered by eastward-flowing river water from eastern outlets of the Mississippi River, as well as low-salinity drainage from Mobile Bay, Alabama, and the island passes of Mississippi Sound. The resulting overlying, low-salinity water probably accounted for the presence of *S. friderici* at stations distant from the more neritic coastal waters.

RESULTS AND DISCUSSION

Description (Figure 3)

Specimens of *Sagitta friderici* from the northeastern Gulf of Mexico have firm translucent bodies with all internal structures clearly visible. Intestinal diverticulae are absent. The collarette is well developed, and when retracted from the head, is distinguishable from the neck region posteriorly to a point about one third of the distance to the ventral

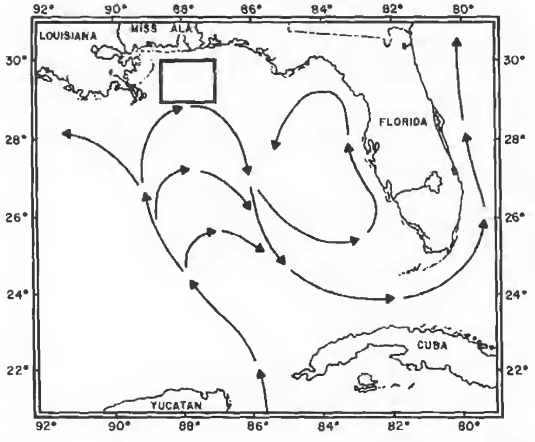

Figure 2. The general path of the Loop Current in the eastern Gulf of Mexico during the summer months (after Leipper 1954). Box indicates study area.

ganglion. The tapered anterior fins emerge at a point equal to the posterior edge of the ventral ganglion and extend posteriorly a length slightly less than that of the posterior fins. The rounded posterior fins are situated with more than half of their length on the caudal segment. Lateral and caudal fins are completely rayed. The seminal vesicles touch the edges of both the posterior and the caudal fins, and when mature, possess a characteristic circular process on the outer anterior portion of the cuticle. Tactile setae, or tangoreceptors, are numerous over the entire body cuticle; notable are a row of four prominent tufts located near the rear edge of the caudal fin and one near the outer edge of each posterior fin. The eyespots are square with one distal and two median clear spaces or "lenses."

Mature specimens varied in length from 6.0 to 9.7 mm in 19 specimens from the BLM samples, and 9.8 to 13.7 mm for 15 OREGON II specimens. The two groups of specimens were identical in all other respects. The taxonomic characters presented in Table 1 were not dependent on length except for three specimens in the 12.4- to 13.7-mm range that had larger numbers of hooks and teeth.

Comparison with Sagitta tenuis

Ovary characteristics are the chief distinguishing features between mature *S. friderici* and *S. tenuis*, a smaller chaetognath but similar in general appearance and morphometric description (Table 1). In *S. tenuis* (Figure 4a), the ovaries are usually confined to a length not reaching the anterior fin and contain ova that are larger and fewer in number than those of *S. friderici*. Mature ova of *S. tenuis* fill the space from intestine to body wall and are attached to the oviduct in single file; however, bunching may often affect their apparent alignment. Ovaries in *S. friderici* usually reach the midpoint of the anterior fin and contain numerous small ova in two or occasionally three rows (Figure 4b).

Ovary differences are illustrated by data presented in Table 2. *S. friderici*'s number of ova per ovary (28.2) nearly doubles the number of ova per millimeter (14.9) indicating the double-row arrangement of ova. A single row of ova is exhibited by *S. tenuis* with its nearly equal number of ova per millimeter (6.4) and ova per ovary (6.5). When these data are applied to the figures for percent of body length comprised by the ovaries, it can be seen that the ova of *S. tenuis*, though fewer in number, are larger in size. This analysis is further demonstrated in Figure 5 which shows for *S. friderici* a rapid increase in number of ova with increasing ovary length to a maximum of 43 ova for an ovary of 3 mm. The increase is more gradual in *S. tenuis*, with a maximum of 10 ova for an ovary of 1.8 mm.

Similar ovarian comparisons have been used by other authors to separate *S. tenuis* and *S. friderici*. Almeida-Prado (1961b), in an excellent account of the Brazilian chaetognaths, noted the size difference between the two species and concluded that the ovarian features of *S. tenuis* are "its principal differential character from *S. friderici*." Furnestin (1966) collected both species off the west coast of Africa and maintained that *S. tenuis*, though very close morphologically to *S. friderici*, can be distinguished by (1) smaller size of mature individuals (5 mm as compared to 8 to 13 mm for *S. friderici*), (2) longer ovaries that reach the middle of the anterior fin (a feature not observed in northeastern Gulf specimens), and (3) fewer ova

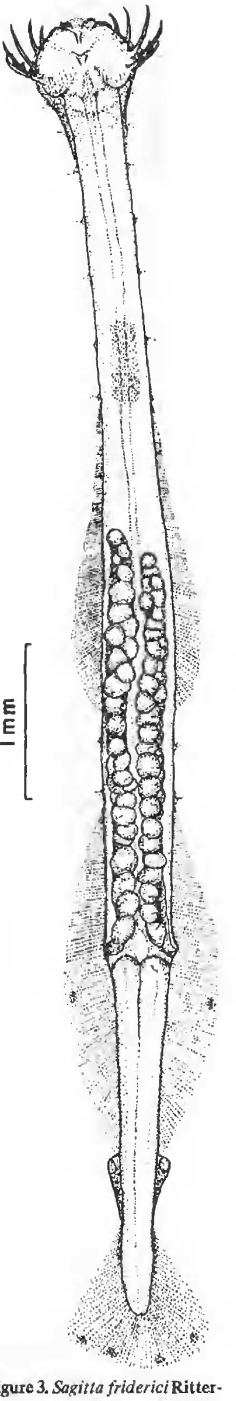

Figure 3. *Sagitta friderici* Ritter-Zahony. Ventral view of whole animal.

TABLE 1.

Comparative morphometric data for mature specimens of *Sagitta friderici* and *S. tenuis* collected in the northern Gulf of Mexico. Range means in paratheses.

	Number of specimens	Length (mm)	Caudal segment percent of length	Number of hooks	Number of anterior teeth	Number of posterior teeth	TC* values
S. friderici							
	5	6.0– 6.4 (6.2)	25.8–30.0 (27.6)	7	5–7 (6.0)	14	55– 84 (73.8)
	9	6.6– 6.9 (6.7)	25.0–30.4 (28.0)	7–8 (7.7)	5–8 (5.9)	13–17 (13.8)	63– 94 (76.2)
	4	7.1– 7.5 (7.2)	26.7–29.2 (27.2)	7–8 (7.5)	6–8 (6.4)	13–17 (14.9)	61–100 (81.4)
	4	7.6– 7.9 (7.8)	25.0–30.4 (27.5)	7–8 (7.5)	6–8 (6.8)	13–17 (14.5)	71– 84 (77.0)
	3	8.1– 8.5 (8.3)	27.2–29.4 (28.8)	7–8 (7.3)	7	14–16 (15.3)	56– 90 (73.3)
	7	9.7–11.6 (10.9)	25.7–30.2 (27.8)	7–8 (7.7)	6–8 (7.1)	15–19 (17.0)	60– 86 (73.4)
	9	12.4–13.7 (12.9)	27.8–29.8 (28.7)	8–9 (8.2)	7–9 (8.3)	17–22 (18.7)	70– 84 (76.1)
Totals and grand means	41	6.0–13.7 (9.2)	25.0–30.4 (28.0)	7–9 (7.7)	5–9 (6.9)	13–22 (15.7)	55–100 (76.0)
S. tenuis							
	1	4.8	31.3	8	6	11	83
	4	5.5– 5.9 (5.7)	24.6–32.2 (28.5)	7–8 (7.3)	5–6 (5.3)	12–14 (13.0)	62– 92 (70.7)
	4	6.0– 6.3 (6.1)	26.7–28.6 (27.8)	7–8 (7.5)	5–6 (5.3)	10–14 (12.0)	65– 89 (71.8)
Totals and grand means	9	4.8– 6.3 (5.8)	24.6–32.2 (28.5)	7–8 (7.5)	5–6 (5.4)	10–14 (12.3)	62– 92 (72.8)

*TC = [(posterior fin length along trunk/posterior fin length along caudal segment) x 100]

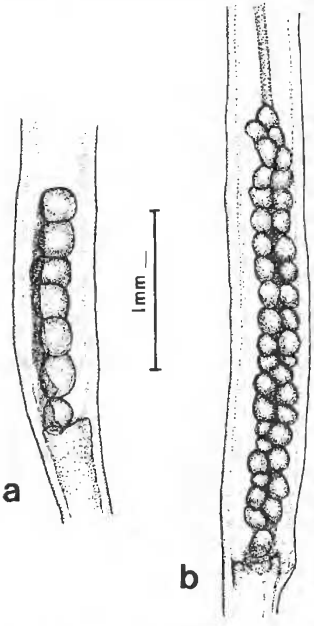

Figure 4. Comparative lateral views of ovaries. (a) *Sagitta tenuis*. (b) *S. friderici*.

(6 to 10 per ovary) which are larger in size, 0.13 to 1.80 mm.

Tokioka (1955, 1961) emphasized the "TC value" (see Table 1) as a means of separating the two species, with *S. friderici* having a substantially greater value than *S. tenuis*. However, Tokioka reported widely varying and often overlapping TC values in specimens he and other workers examined from several parts of the world. Grant (1963) also reported such an overlap when he compared TC values of his Virginia specimens of *S. tenuis* with those of *S. tenuis* from Florida, and *S. friderici* from Morocco as reported by Tokioka (1955). Likewise, no conclusive evidence of species separation was obtained when the TC method was applied to mature northeastern Gulf specimens (Table 1), because *S. tenuis* had values well within the range of *S. friderici*. Tokioka's method appears to be dependent on well-preserved, undamaged specimens, conditions not usually found in the average plankton sample due to the delicate nature of the animals. Moreover, TC values probably vary among breeding populations in the same manner as numbers of hooks and teeth, and as such, should not be regarded as an important means of separating the two species.

TABLE 2.

Comparison of mean values of distinguishing characteristics between mature specimens of *Sagitta friderici* and *S. tenuis*.

	S. friderici	*S. tenuis*
Number of specimens	30	9
Total length (mm)	9.2	5.8
Ovary length (mm)	1.9	1.1
Number of ova/ovary	28.2	6.5
Number of ova/mm ovary	14.9	6.4
[(ovary length/body length) x 100]	21.2	19.0

Distribution

Sagitta friderici was the dominant chaetognath at the more landward BLM stations over the continental shelf, with a maximum of 40 individuals per m^3 at M13 (see Figure 1). It was also present in limited abundance in the upper water levels over the edge of the continental shelf. The majority of specimens were collected in the salinity range 24.9 to 33.9 ppt (80%), in the temperature range 23.0 to 30.3°C (93%), and in waters with oxygen content above 5.0 mg/l (99%). The species occurred predominantly in the epipelagic region

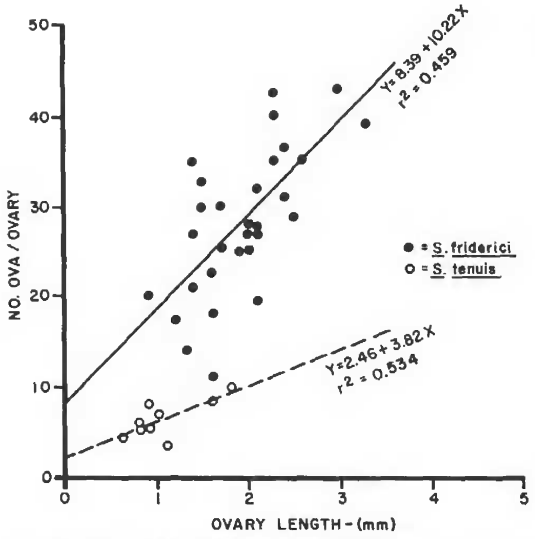

Figure 5. Comparative relationships of number of ova per ovary to ovary length for *Sagitta friderici* and *S. tenuis*.

(0 to 20 m); however, two specimens were present in a sample collected from 88 to 166 m at station A7.

Sagitta friderici probably occurs in less saline waters further inshore from the present study area; indeed, such salinity tolerance has been recorded in the literature. Laguarda-Figueras (1967) observed it in salinities as low as 14.0 ppt in the Laguna de Terminos. However, Fraser (1961) found *S. friderici* abundant along the coast of Nigeria in salinities between 11.5 and 12.0 ppt, and suggested that neither salinity nor temperature above 10°C influenced its distribution.

Some authors have commented on ecological barriers separating *S. friderici* and *S. tenuis*. According to Tokioka (1961), *S. tenuis* generally is found in protected embayments while *S. friderici* is confined to the more open neritic water mass. Furnestin (1966) reported a small population of *S. tenuis* near the mouth of the Congo River in salinities ranging from 22.0 to 24.0 ppt. She found this population to be equatorially centered along the western coast of Africa and generally separate from populations of *S. friderici* located in more saline waters to the north and south. In the northeastern Gulf, *S. friderici* and *S. tenuis* appeared to occupy basically the same habitat. Boundaries could not be determined between the two populations mainly because of the mixed surface waters characteristic of the region. Intensive monthly sampling in this and adjacent regions, both inshore and offshore, may provide a better definition of the population dynamics of these two neritic species in the northern Gulf of Mexico.

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